

**International Atomic Energy Agency**

**IAEA NDS – 50 years**

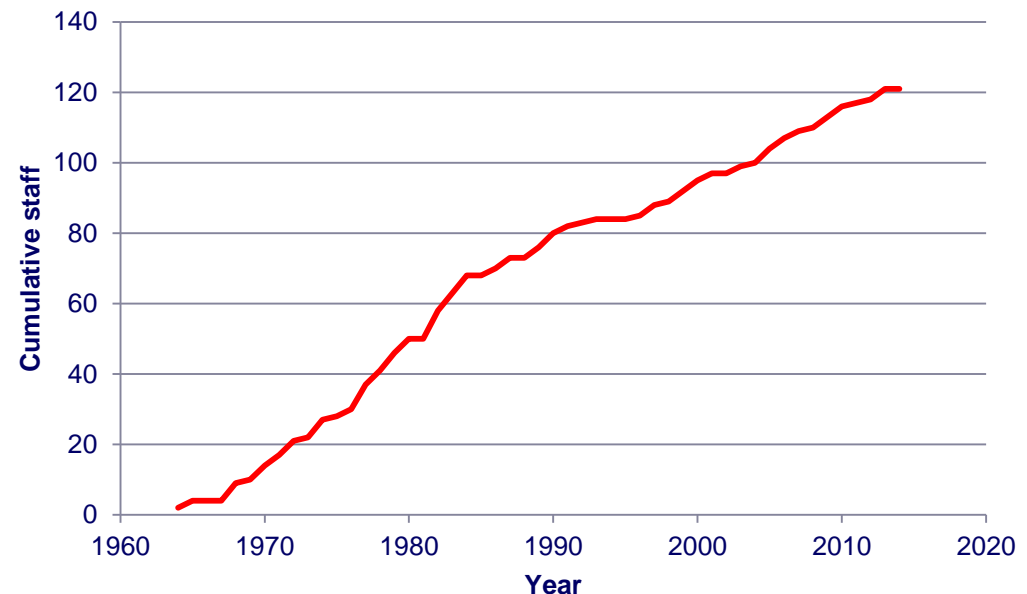
**R.A. Forrest**

**Nuclear Data Section**

**Department of Nuclear Sciences and Applications**

# Staff

- Since 1964 a total of 135 staff have worked in the NDS
- The average size of the Section has been 18.6 (currently it is 16)
- Of those known 59% have been male and 41% female
- 8 Section Heads
- Cumulative number for 121



# What we do

**INTERNATIONAL NUCLEAR DATA SCIENTIFIC WORKING GROUP**

Recommendations of the First Meeting

27-31 May 1963

- ... to foster exchange of information on ND ...  
IAEA collect relevant data
- List data needs
- Compile available data, stimulate new experiments
- Review 2200 m/s data for 4 fissile nuclides



# What we do

- **Bibliographic data - CINDA**
- **Data needs – WRENDA (discontinued)**
- **Compile data – EXFOR**
- **Coordinate networks**
- **Provide wide range of databases**
- **Produce data – CRPs and DDPs**
- **Provide authoritative documents**
- **Disseminate data - website**
- **Provide training**





Request



CD/DVD with documentation, data, codes, etc.

Quick Links

- ADS-Lib
- Atomic Mass Data Centre
- CINDA
- Charged particle reference cross section
- DROSG-2000
- EMPIRE-3.2
- ENDF Archive
- ENDF Retrieval
- ENDF-6 Codes
- ENDF-6 Format
- ENSDVER
- ENSDF
- ENSDF ASCII Files
- ENSDF programs
- EXFOR
- FENDL 3.0
- Fission Yields
- GANDR
- Geant4 Libraries
- IBANDL
- INDL/LSL

**NEW**

**JEFF-3.2** - Joint Evaluated Fission and Fusion File, coord. by NEA Data Bank, 2014 [page] [archive] [retrieve]

**IRDF** - International Reactor Dosimetry and Fusion File v1.03 [page] [archive] [retrieve]

**CD/DVD-ROMs** available for on-line downloading [page]

**Portable Empire-3.2.2** for Windows - nuclear reaction model code system for data evaluation [page] [download]

- Main | All | Reaction Data | Structure & Decay | by Applications | Doc & Codes | Index | Events | Links | News



**EXFOR**

Experimental nuclear reaction data



**LiveChart of Nuclides**

Interactive Chart of Nuclides



**CINDA**

Nuclear reaction bibliography



**ENDF**

Evaluated nuclear reaction libraries



**ENSDF**

evaluated nuclear structure and decay data (+XUNDL)



**NSR**

Nuclear Science References \*

**NuDat 2.6**

selected evaluated nuclear structure data \*\*

**RIPL**

reference parameters for nuclear model calculations

**IBANDL**

Ion Beam Analysis Nuclear Data Library

**Charged particle reference cross section**

Beam monitor reactions

**PGAA**

Prompt gamma rays from neutron capture

**FENDL 3.0**

Fusion Evaluated Nuclear Data Library, Version 3.0

**Photonuclear**

cross sections and spectra up to 140MeV

**IRDF**

International Reactor Dosimetry and Fusion File

**NAA**

Neutron Activation Analysis Portal

**Safeguards Data**

recommendations, August 2008

**Medical Portal**

Data for Medical Applications

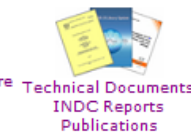
**Standards**

- Neutron cross-sections, 2006  
- Decay data, 2005

\*Database at the IAEA, Vienna

\*\*Database at the US NNDC

**IAEA Nuclear Data Section**



Mirrors

Partners

Events <1:2>



**International Workshop on Nuclear Data Covariances (CW2014)**  
April 28 - May 1, 2014  
La Fonda on the Plaza, Santa Fe, New Mexico, USA



**15th International Symposium on Reactor Dosimetry (ISR-15)**  
May 18-23, 2014  
Aix en Provence, France



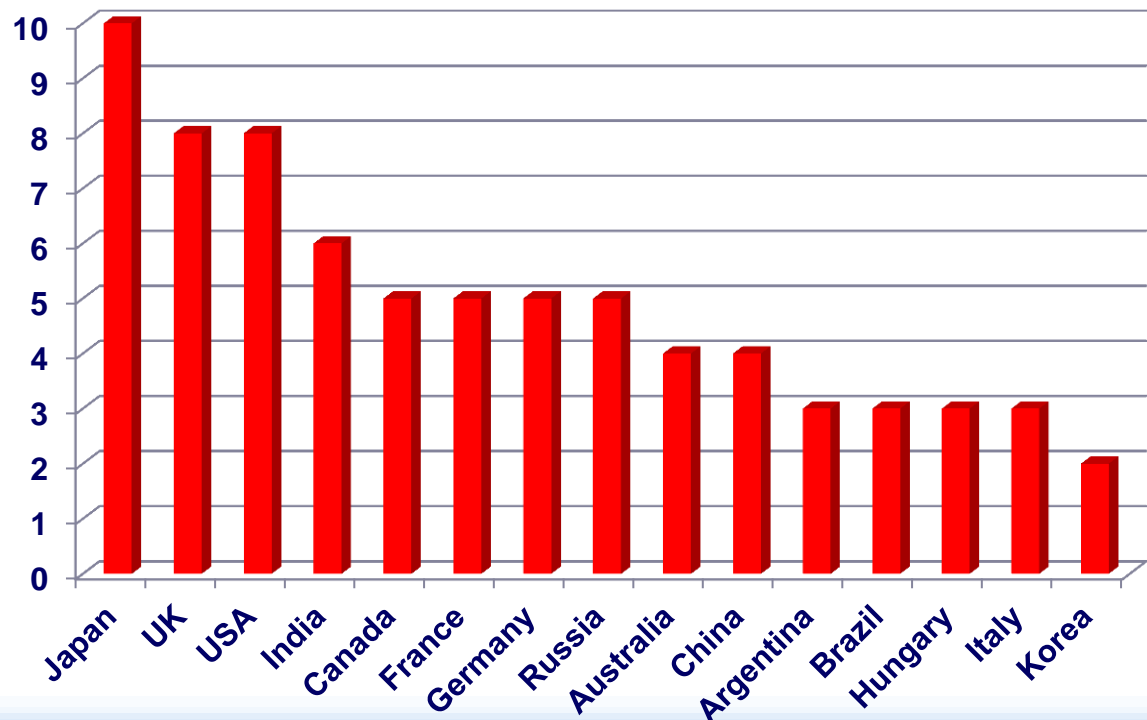
# Networks

- The '***Four Centre Network***' was in operation from 1967 and has evolved into the ***NRDC*** containing the same Four 'Core' Centres with a further 9 specialised Centres
- NRDC coordinated by NDS, meetings annually with every second meeting one for Centre Heads
- Maintains EXFOR and CINDA



# INDC

- **The *International Nuclear Data Scientific Working Group (INDSWG)* was renamed the *International Nuclear Data Committee (INDC)***
- **About to hold its 30th meeting**
- **86 members**
- **+12 countries**



# Nuclear Data types

- **Information about nuclides – decay properties and structure (energy levels)**
- **How nuclides interact with particles – reaction properties (e.g. reaction cross sections)**
- **Needed for basic science and for all nuclear applications**
- **Why do we need more data when nuclear reactors work and nuclear medicine is routine?**





# Nuclear Data

- Thermal fission reactors needed basic data, but then could rely on small scale experiments to ‘tweak’ data
- Approach does not work for fusion, nor for new generations of fast reactors
- Need now for data for wide range of targets, energies and quantities
- Cannot all be provided by experiment (expensive), so need reliable predictions – found in evaluated files

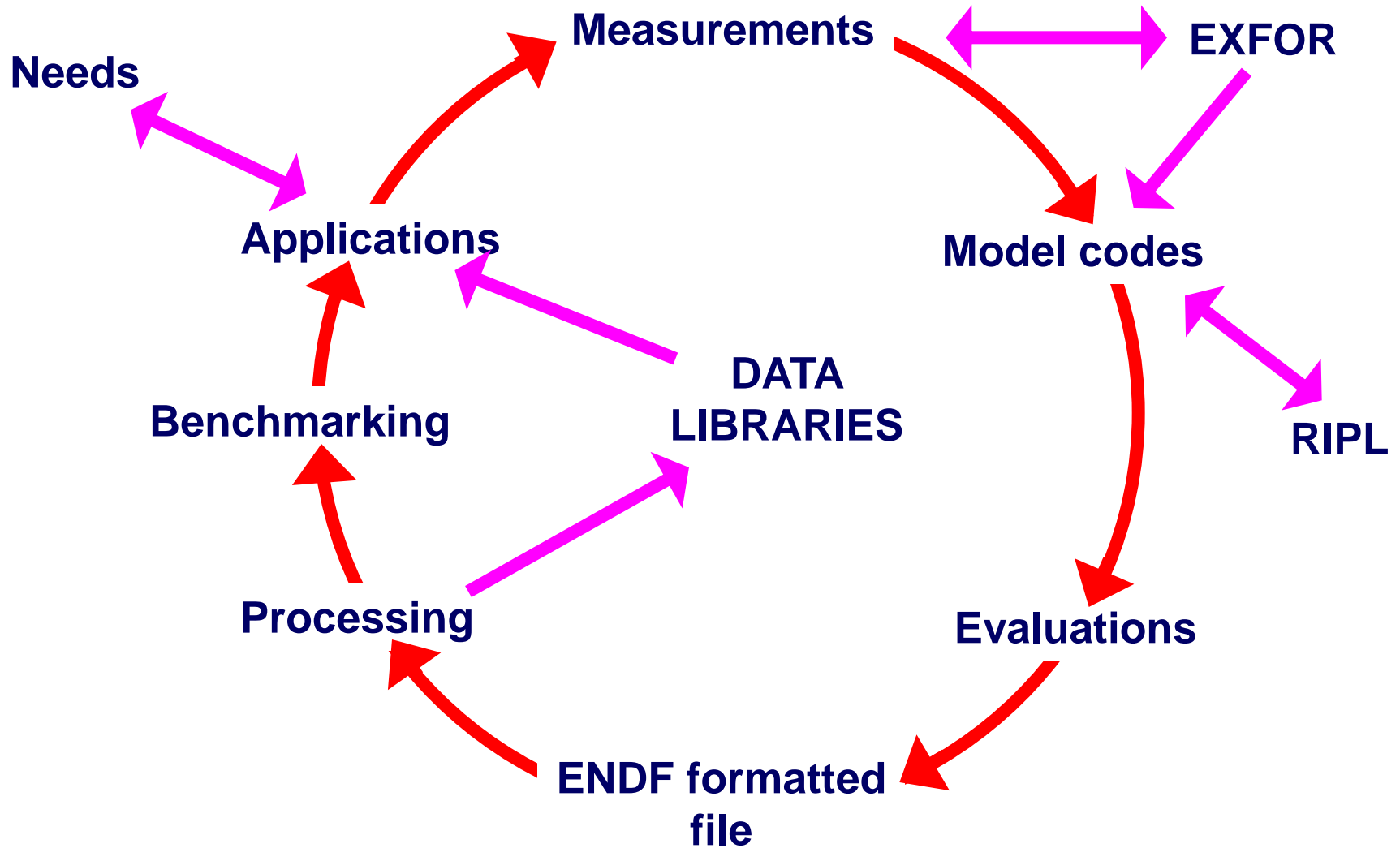


# Nuclear Data cycle

- **Experiment – data for limited number of reactions and energies**
- **Compile into EXFOR**
- **Make calculations using theoretical knowledge (RIPL for inputs)**
- **Combine into evaluation – best estimate of everything**
- **Store data in Formatted file**
- **Process into application library**
- **Benchmark use**
- **Find shortcomings – start again!**

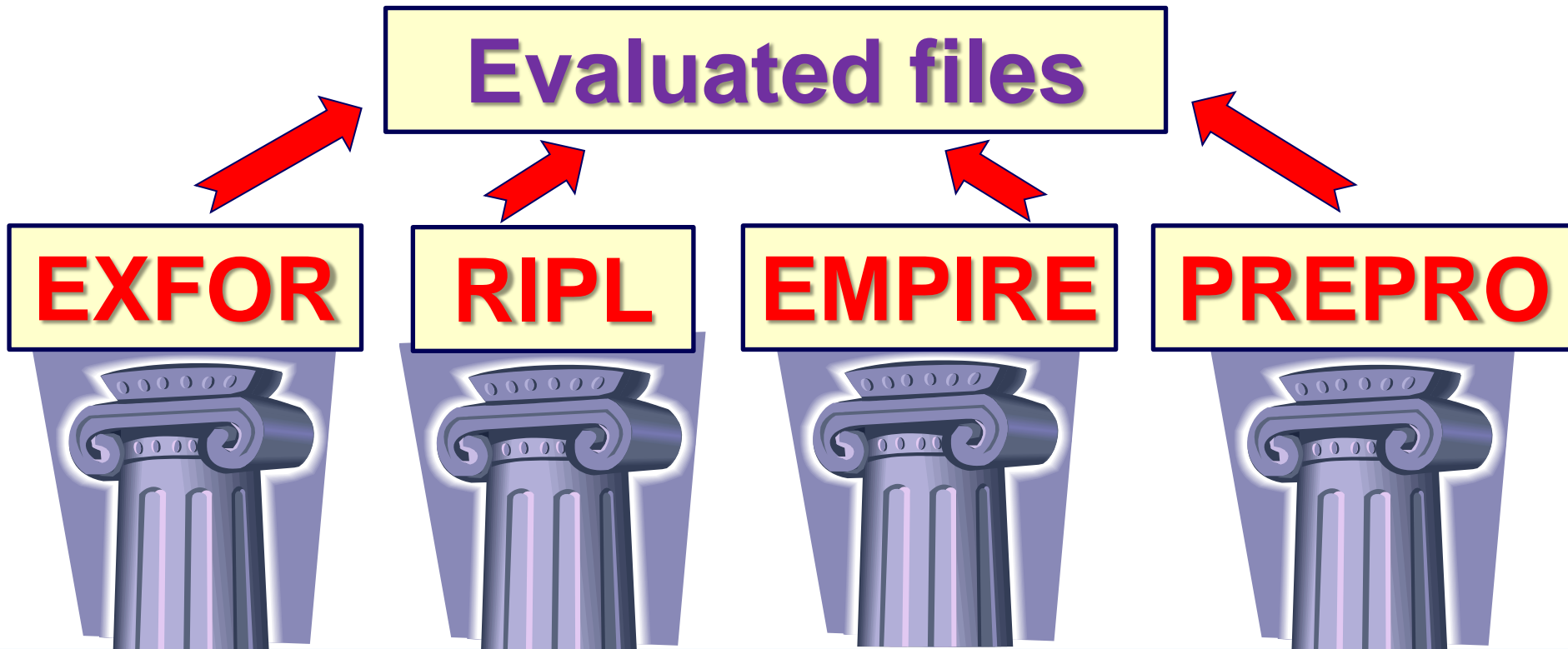


# Nuclear data



# NDS contributions

- NDS does not carry out experiments (neither the differential nor the integral benchmarking)
- Contributes to everything else



# Formats

- Data are often thought of as just ‘tables’ such as cross section as a function of neutron energy
- Need much more:
  - Description of experiment
  - Uncertainty analysis
- A data file must contain text + numbers, organised in a standard way → Format
- For experiments – EXFOR Format
- For evaluated files – ENDF Format



# Formats

- **Both the EXFOR and ENDF formats have acted as standards, but because of their success they are now very difficult to change**
- **Change requires resources, effort and planning; does the international community have these?**
- **This may be a major challenge to Nuclear Data over the next 10 years**

# Evaluated files

- Evaluated files have been produced by individual countries for decades. These are used primarily by industries for building reactors
- A major area of work for NDS was the FENDL project, data needed for fusion reactors
- Specialists meeting in November 1987
- A CRP led to FENDL-1 in 1995, but perhaps more important than the *product* was the *process* of evaluation inter-comparison (Review kits)



# Evaluated files

- The Review kits were the first time a systematic comparison of multiple evaluations (ENDF, BROND, JENDL, EFF and ENDL)
- Today, this is commonplace and can be done interactively using NDS website
- Personally the 1987 meeting was my 'introduction' to the Agency

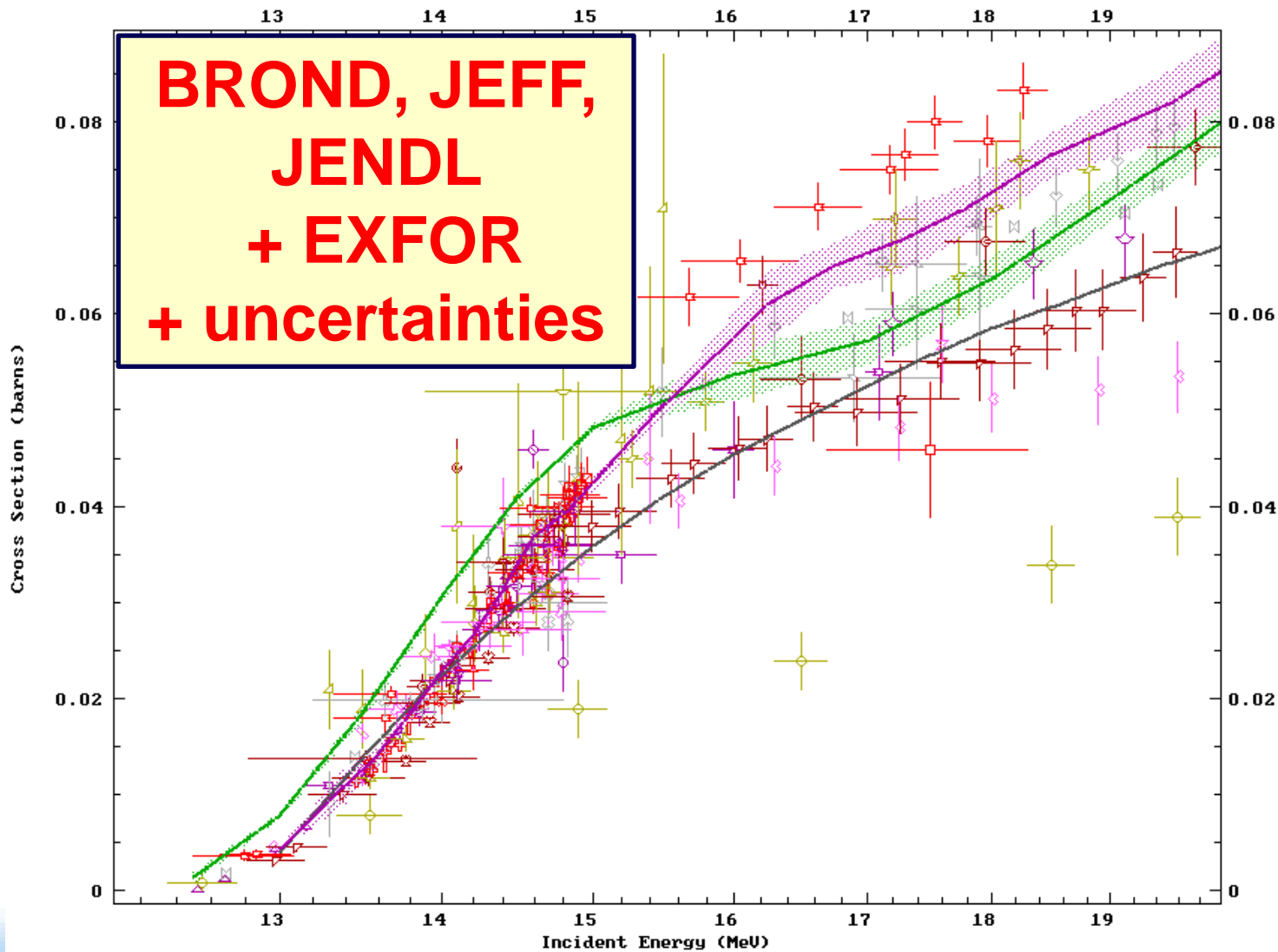
8. F. Mann (Hanford): REAC-activation data file.
9. J. Kopecky (ECN, Petten): Activation data library and isomeric ratios systematics
10. R. Forrest (AERE, Harwell): Activation data library of UK and systematics of 14.5 MeV charge particle production.





# $^{58}\text{Ni}(n,2n)$

28-Ni-58(N,2N), SIG



# Future for evaluated files

- **Will there continue to be separate, independent regional libraries?**
- **Files are big, more complicated, more comprehensive than previously, but reduced effort and expertise available ⇒**
- **More international collaboration**
- **Already WPEC, CRPs and CIELO**
- **Role for IAEA in coordination?**
- **Another challenge for the future**



# Computing

- **NDS has been in leading edge of IT in the IAEA:**
  - **1<sup>st</sup> mainframe needed for Nuclear Data work**
  - **Used IBM mainframes until 1991**
  - **NDS acquired its own VAX**
  - **1985 use of PCs**
  - **1988 e-mails for communication with Data Centres**
  - **1<sup>st</sup> website in 1996**
  - **1999 NDS acquires Compaq Alpha Server model DS20**
  - **2000 current web address**
  - **2004 use of Linux**
  - **2013 Web servers in the cloud**



# Training

- There has been a long-standing collaboration of IAEA with ICTP, from 1969 with “The Structure of Nuclei” lectures lasting for 2 months in Trieste
- In 1978 NDS held a four week Course on “Nuclear Theory for Applications” in Trieste
- The length of courses has decreased, but we regularly hold 2 workshops per year, in 2014 it will be 3

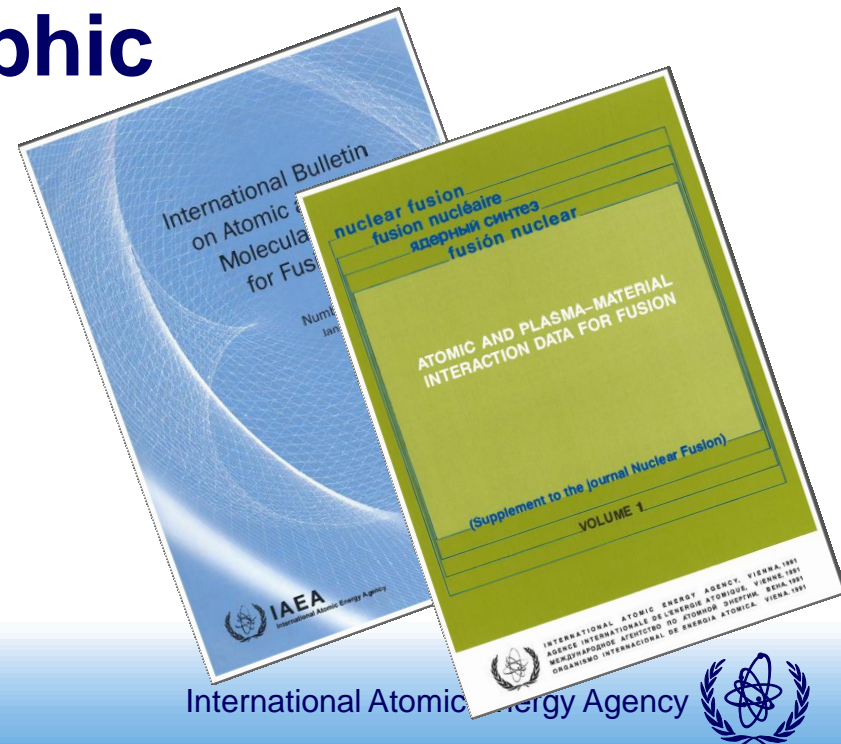
## **Atomic and Molecular Data**

- **1977 Formation of Atomic and Molecular (A+M) Data Unit headed by Earl Beatty**
- **1981 First meeting of the IFRC Subcommittee on Atomic and Molecular Data for Fusion, acts as Review body for A+M in the same way as INDC does for Nuclear**
- **Work is focused on need for fusion**
- **Main achievements have been ALADDIN database (1988), AMBDIS bibliography and in 2010 a wiki Knowledge Base**
- **Published documents**



# A+M Data

- The APID publications (since 1991) cover results from important meetings and CRPs
- Bulletins (most recent in 2013 in Volume 69) contains bibliographic information
- Data now held in separate server in the Cloud






# Android App


- A new approach to data dissemination is to target users with tablets and smartphones
- The Android App '*Isotope Browser*' was released last year and with > 5,500 downloads has been well received
- Presents summary data for 4,000 nuclides using ENDSF database
- See <http://play.google.com/store/apps>





# Android App



**Isotope Browser**  
 IAEA Nuclear Data Section
 

 **Chart**

 **Elements**

 **Go**

 **Clear**

 **Advanced**

**21 nuclides for "Element Na order by Z, N":**

<b>20 Na</b> 11	447.9 (23) ms	2+	ec 100.0%
<b>21 Na</b> 11	22.49 (4) s	3/2+	ec β+ 100.0%
<b>22 Na</b> 11	2.6027 (10) Y	3+	ec β+ 100.0%
<b>23 Na</b> 11	Stable	3/2+	Abundance100%
<b>24 Na</b> 11	14.997 (12) H	4+	β- 100.0%
<b>24 Na<sub>m</sub></b> 11	20.18 (10) ms	1+	IT 99.95%
<b>25 Na</b> 11	59.1 (6) s	5/2+	β- 100.0%





# Main themes

- EXFOR/CINDA
- RIPL
- Fusion data, Nuclear and A+M
- Medical
- Analytical
- Standards
- International Networks
- EMPIRE
- PREPRO
- Website, data + tools
- Training
- Documents

# People

- **I started by talking about people, but only the statistics**
- **The main reason that NDS has been so effective and productive over 50 years is the people**
- **So, I want to finish with some photographs, many very sad because people are no longer with us, but also some good memories and I hope that the Section will continue with the same spirit into the next half century!**



1982



1996



2009



2009



# 2010



# 2012 INDC





# 2013 NRDC



# Thank you!

